

## **SURGICAL IRRIGATION PUMP AND TOOL SYSTEM**

[0001] This application claims priority U.S. Provisional Patent Application Serial No.  
5 60/462,650, filed April 14, 2003.

### **TECHNICAL FIELD**

[0002] This invention relates to a surgical irrigation pump and tool system.

### **BACKGROUND OF THE INVENTION**

10 [0003] Supplying irrigation liquid to a surgical site via a surgical handpiece from a peristaltic pump on a remote console has been long known. One such pump and console is disclosed in U.S. Patent 6,007,556 issued December 28, 1999 to Joseph Kablik et al.

The Kablik irrigation surgical tool system includes a motorized handpiece with a tool removably insertable therein. The console includes a peristaltic pump rotor and a tube  
15 set. The tube set is housed within a cassette which is mountable on the console for coaction with the rotor to supply irrigation liquid to the tool.

[0004] The Kablik cassette mounts on the outside of the console, through a set of tabs which, and over a set of pump rollers which are outside of the console. The pump rollers are mounted to a shaft which is rotated by the pump. Rotation of the shaft and the pump  
20 rollers compress the tubes within the cassette, thereby providing a pulsatile flow of irrigation fluid. However, since the pump rollers are external to the console, they are susceptible to contamination which may lead to failure and/or additional cleaning.

[0005] The present invention is aimed at one or more of the problems identified above.

## SUMMARY OF THE INVENTION AND ADVANTAGES

[0006] The present invention relates in one aspect to an irrigation surgical tool system including a motorized handpiece, a tool removably insertable therein, a console including a peristaltic pump rotor and a tube set including a cassette mountable on the console for  
5 coaction with the rotor to supply irrigation liquid to the tool. The invention relates in another aspect to a tool having a rotating inner tube within a fixed outer tube. An irrigation liquid passage between the tubes communicates with the inner tube and thence through tissue working windows in the inner and outer tubes with a surgical site for alternately supplying irrigation liquid to the surgical site and removing, by entrainment,  
10 of debris from the surgical site by means of suction in the inner tube.

[0007] Further objects and purposes of the invention will be apparent to persons acquainted with apparatus of this general type upon reading the following description and inspecting the accompanying drawings.

## BRIEF DESCRIPTION OF THE DRAWINGS

15 [0008] Other advantages of the present invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

[0009] FIG. 1 is a somewhat schematic view of a surgical irrigation pump system embodying the invention;

20 [0010] FIG. 1A is a diagrammatic illustration of a surgical irrigation pump system with an insertable cassette, according to an embodiment of the present invention;

[0011] FIG. 1B is a second diagrammatic illustration of the surgical irrigation pump system of FIG. 1A;

- [0012] FIG. 2 is a schematic cross-sectional view of the cutter of FIG. 1;
- [0013] FIG. 3 is a view similar to FIG. 2 with irrigation but not suction applied;
- [0014] FIG. 4 is an elevational view of the FIG. 1 cutter;
- [0015] FIG. 5 is an enlarged fragmentary central cross section of the FIG. 4 cutter;
- 5 [0016] FIG. 5A is a fragmentary enlargement of FIG. 5;
- [0017] FIG. 5B is an enlarged fragment of FIG. 5 showing in cross-section a modified tool fragment, the modification including an annular seal interposed between the fixed and rotating hubs of the tool;
- [0018] FIG. 6 is an enlarged fragmentary partially broken view of the FIG. 4 cutter;
- 10 [0019] FIG. 7 is an enlarged fragment of FIG. 5 showing in cross section a handpiece fragment for resiliently retaining the tubular mounting hub of the tubular outer housing;
- [0020] FIG. 8 is a fragmentary exploded view of the FIG. 1 handpiece and cutter, showing same positioned prior to insertion of the rear end of the cutter into the front end of the handpiece;
- 15 [0021] FIG. 9 is an elevational view similar to FIG. 8;
- [0022] FIG. 10 is an elevational view similar to FIG. 9 but showing the cutter and handpiece engaged in an operating position;
- [0023] FIG. 11 is a fragmentary view of the outer tube of the cutter;
- [0024] FIG. 12 is a sectional view substantially taken on the line 12--12 of FIG. 11;
- 20 [0025] FIG. 13 is a central cross-sectional view substantially taken on the line 13--13 of FIG. 11;
- [0026] FIG. 14 is a right end view of the FIG. 13 outer tube;

- [0027] FIG. 15 is a fragmentary elevational view of the cutter outer tube of FIGS. 11-14 taken generally along the line 15--15 of FIG. 12;
- [0028] FIG. 16 is a pictorial view of the tubular mounting hub of the outer housing of the FIG. 4 cutter;
- 5 [0029] FIG. 17 is a central cross-sectional view thereof;
- [0030] FIG. 18 is an enlarged fragment, indicated at 18--18 of FIG. 17;
- [0031] FIG. 19 is a pictorial view of a drivable rotor hub of the inner rotor of the FIG. 4 cutter;
- [0032] FIG. 20 is an elevational view of the inner rotor of the FIG. 4 cutter;
- 10 [0033] FIG. 21 is an enlarged central cross sectional view substantially taken on line 21--21 of FIG. 20;
- [0034] FIG. 22 is an elevational view of the inner tube of the FIG. 20 inner rotor, taken from the bottom thereof in FIG. 20;
- [0035] FIG. 23 is an enlarged fragment of the forward end portion (rightward in FIG. 20) of the FIG. 20 and 22 rotatable inner tube;
- 15 [0036] FIG. 24 is a view similar to FIG. 23 but taken from the opposite side thereof, namely from the bottom in FIG. 20 and showing an enlarged fragment of FIG. 22;
- [0037] FIG. 25 is a central cross sectional view of the FIG. 23 inner tube forward end portion taken substantially on the line 25--25 of FIG. 22;
- 20 [0038] FIG. 26 is a transverse cross sectional view substantially taken on the line 26--26 of FIG. 25;
- [0039] FIG. 27 is an enlarged fragmentary transverse cross sectional view substantially taken on the line 27--27 of FIG. 25;

[0040] FIG. 28 is an enlarged fragmentary transverse cross sectional view substantially taken on the line 28--28 of FIG. 25;

[0041] FIG. 29 is an enlarged fragmentary elevational view of the forward end of the fixed outer tube generally similar to the orientation of FIG. 13 but taken from the opposite side thereof and showing a modification of the cutting window;

[0042] FIG. 30 is a pictorial view of the modified FIG. 29 device;

[0043] FIG. 31 is a front view of a pump cassette of the kind shown installed in pumping position on the FIG. 1 pump console;

[0044] FIG. 32 is a rear view of the FIG. 31 cassette;

[0045] FIG. 33 is a pictorial view of the FIG. 31 cassette taken from the angle to show the top, left side and front thereof;

[0046] FIG. 34 is a similar pictorial view of the rear of the FIG. 33 cassette showing primarily the rear and left side thereof;

[0047] FIG. 35 is a fragmentary front view of the FIG. 1 console showing the peristaltic pump mounting plate with the FIG. 1 and 31 cassette removed;

[0048] FIG. 36 is a sectional view substantially taken on the line 36--36 the FIG. 35 with the cassette installed on the console;

[0049] FIG. 37 is a view similar to FIG. 36 but with a pump cassette installed in pumping position on the console mounting face;

[0050] FIG. 38 is a cross-sectional view substantially taken on the line 38--38 of FIG. 35 with the cassette installed on the console;

[0051] FIGS. 39A-39H are isometric drawings of an insertable cassette, according to a first embodiment of the present invention;

[0052] FIGS. 40A-40J are isometric drawings of an insertable cassette, according to a second embodiment of the present invention;

[0053] FIGS. 41A-41J are isometric drawings of an insertable cassette, according to a third embodiment of the present invention;

5 [0054] FIGS. 42A-42H are isometric drawings of an insertable cassette, according to a fourth embodiment of the present invention; and,

[0055] FIGS 43A & 43B are isometric drawings a pump rotor assembly, according to an embodiment of the present invention.

10 [0056] DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0057] An irrigation cutter system 10 (FIG. 1) comprises a motorized handpiece 11 removably supporting and driving a tool 12 insertable into a surgical site SS for working (e.g. cutting) patient tissue in the surgical site. The system 10 further includes a console 13 preferably located remote from the handpiece 11 and surgical site SS and a tube set 15 14 removably connectable with the console 13 and cooperable therewith for pumping irrigation liquid from a conventional irrigation liquid source, such as a conventional bag IB, to the handpiece 11. The handpiece 11 may be substantially conventional and, for example, similar to cutter handpieces marketed by Stryker Corporation under the trademark HUMMER I.

20 [0058] Thus, the handpiece 11 includes a power rotation source (e.g. electric motor), 15 indicated schematically in dotted lines in FIG. 1, contained in a hand held casing 20. The handpiece is supplied operating power for its powered rotation source 15 from any convenient power source schematically indicated at PO, such as a conventional electric

power source of the type used to operate conventional surgical powered handpieces. The handpiece 11 is here provided with an internal suction path by which it can apply suction to the tool 12 in a substantially conventional manner, from a suitable suction source SU, as schematically indicated in dotted line in FIG. 1. The power source PO and suction source SU may be connected to the handpiece 11 in any conventional manner, as in FIG. 1 through a common flexible cable 21 containing side by side insulated electric wires and a suction hose, not shown, or through separate flexible electrical cable and suction hose runs, as schematically indicated in FIGS. 9 and 10. The power source PO can be controlled (e.g. turned on and off or varied) in any conventional manner, either directly by the user, or, as indicated schematically by the dotted line at 22, by suitable controls on the console 13 and operable by the user.

[0059] A tool 12 embodying the invention is shown in elevation in FIG. 4 and schematically in cross section in FIGS. 2 and 3. FIGS. 2 and 3 schematically show the basic parts of the tool 12. The tool 12 here comprises a tubular radially outer housing 30 including a tubular mounting hub 31 for fixed but releasable mounting on the forward portion of the casing 20 of the handpiece 11 and an outer tube 32 fixedly projecting forward from the mounting hub 31. The mounting hub and outer tube have communicating coaxial bores 33 and 34 defining a common radially outer passage 35.

[0060] The tool 12 further includes a tubular radially inner rotor 40 including a rotor hub 41 rotatably drivable by the power rotation source 15 of the handpiece 11 (FIG. 1), and an inner tube 42 fixedly projecting forward from the rotor hub 41. The rotor hub and inner tube have communicating coaxial bores 43 and 44 defining a common radially inner fluid passage 45.

[0061] The inner tube 42 is rotatably housed in the outer tube 32 and associated outer tubular mounting hub 31, extending axially from substantially the front (right in FIGS. 2 and 3) end of the outer tube 32 rearwardly (leftwardly in FIGS. 2 and 3) to the outer tubular mounting hub 31, to coaxially fixedly engage the rotor hub 41.

5 [0062] Although it is contemplated that the present invention may be applicable to surgical tools of different kind, in the particular embodiment shown the forward ends of the outer and inner tubes are at least partially closed (here providing an end thrust bearing effect therebetween), and the front end portions of such outer and inner tubes are each provided with sidewardly and/or radially opening, circumferentially alignable, patient  
10 tissue engaging windows, namely an outer window 46 and an inner window 47. In the particular embodiment shown, at least one window 46 or 47 has a cutting edge for cutting patient tissue upon rotation of the inner tube 42 within the outer tube 32. The rotation of the inner tube with respect to the outer tube thus periodically substantially radially aligns the inner window 47 with the outer window 46 and allows, at that time, communication  
15 between the inner fluid passage 45 and outer window 46.

[0063] The rotor hub 41, as schematically shown in FIGS. 2 and 3, has a hole 52 opening from the bore 43 which communicates through the handpiece 11 with the suction source SU as schematically shown in, and discussed above with respect to, FIG. 1.

[0064] To the extent above described, the tool 12, in its embodiment here shown, is  
20 substantially similar to conventional endoscopic suction cutters.

[0065] Turning now in more detail to the hollow outer housing 30, its mounting hub 31 (FIGS. 6 and 16-18) is conveniently constructed as a molded plastics member and is substantially rigid. The mounting hub 31 externally comprises a substantially cylindrical



rear portion 53, an annular groove 54, a circumferential rib 55 and an elongate, somewhat forwardly tapering, forward portion 56. The annular groove 54 is occupied by a resilient seal ring, here a conventional O-ring 57, which protrudes radially outwardly therefrom for sealing engagement against a bore periphery in the front end, or chuck portion, 61 (FIG. 7) of the handpiece 11, for preventing leakage of liquid from the surgical site rearward along the outside of the mounting hub into the handpiece 11. It will be understood that the chuck portion 61 of the handpiece 11 is shown somewhat schematically to more clearly illustrate the features of the invention.

[0066] In the preferred embodiment shown, the tool 12 is chucked in the handpiece chuck 61 by displacing axially the outer chuck part 67 rearward against a spring 66 back by the handpiece casing 20 (FIG. 7). The chuck portion 61 includes a bore 62 which then receives the rear portion 53 of the fixed mounting hub 31 (as well as the portion of the inner rotor 40 to the rear thereof). Rearward displacement of the tool 12 with the respect to the chuck portion 61 is positively stopped by abutment of the rear face of the circumferential rib 55 against a forward facing step 63 defining the rear end of a forward opening recess 64 communicating with the forward end of the bore 62. Thus the chuck recess 64 rearwardly receives the rib 55 fully thereinto. The chuck 61 here illustrated includes a latch member 65 (here for example a ball) normally cammed radially inward by a ramp on the surrounding outer chuck part 67 with part 67 normally urged forward by the spring 66. However, with the outer chuck part 67 displaced rearward from its FIG. 7 position, the ball 65 can float radially out beyond the perimeter of the tool ridge 55. Thus, upon rearward insertion of the tool 12 in the chuck portion 61, the ridge 55 easily pushes the ball 65 radially outward out of the way to allow such ridge 55 to move into

rearward abutment with the chuck step 63. The user then releases the chuck outer part 67 and the latter is displaced forward its FIG. 7 position by the spring 66, thus positively camming the ball 65 radially inward to its FIG. 7 position in front of the circumferential rib 55 of the tool 12. The front edge of the circumferential rib 55 is provided with  
5 circumferentially spaced substantially spherical notches 71 (FIGS. 6, 7 and 16) shaped and sized to receive the rear, radially inner portion of the ball 65, so as to urge the tool 12 rearward against the chuck step 63 and retain the tool 12 axially and circumferentially fixed in place in the chuck.

[0067] To remove the tool 12 from the chuck, one need merely again displace the  
10 chuck part 67 rearward, then displace the tool 12 forward (the circumferential rib 55 camming the floating ball 65 radially outward out of its way) and release the chuck part 67.

[0068] The notches 71 prevent inadvertent rotation of the tool mounting hub 31 within the handpiece 11 due to interference with the ball 65 with the unnotched portions 72 of  
15 the forward edge of the circumferential rib 55.

[0069] In the embodiment shown, one of the notches 71, namely one indicated at 71A in FIG. 16, is circumferentially elongate to permit limited angular displacement of the mounting hub 31 with respect to the handpiece, if the circumferentially elongate notch 71A is the one engaged by the ball 65.

20 [0070] It is contemplated that more than one radially inwardly resiliently biased ball 65 may be supplied and in the embodiment shown, three such balls are preferably provided in evenly circumferentially spaced (e.g. 120.degree.) relation. As seen in FIG.

16, two circumferentially spaced elongate notches 71A are provided in the circumferential rib 55.

[0071] The mounting hub 31 has a substantially radially outward extending hollow fitting, here in the form of a nipple 73 (FIGS. 5, 6 and 16), near the front end thereof and  
5 spaced forward from the circumferential rib 55 and handpiece chuck portion 61 (FIG. 10). The fitting 73 includes a through passage 74 for irrigation liquid, extending through the radially outer end of the nipple 73 and thence radially inward therefrom into the central bore 33 of the mounting hub 31. See also FIG. 17. The outer end of the nipple 73 is connectable to communicate with an outflow hose portion, hereafter described at 204, of  
10 the tube set 14 (FIG. 1).

[0072] The front end of the bore 33 is chamfered as indicated at 75 in FIG. 17 to facilitate installation of the rear end of the outer tube 32 rearwardly into the bore 33 of the mounting hub 31 to allocate same therein in the manner indicated in FIGS. 5 and 6.

[0073] The outer tube 32 (FIGS. 11-15) comprises an elongate cylindrical rearward  
15 portion 80 from which forwardly coaxially extends a substantially shorter hollow tubular nose piece 81. The nose piece 81 has slightly lesser inner and outer diameters than the elongate cylindrical rearward portion 80 and is joined thereto by any convenient and conventional means, for example, integrally, as by radially inwardly deforming the nose piece, or by laser welding or the like of initially separate pieces 80 and 81. The joiner  
20 defines circumferential external and internal steps 82 and 83 (FIG. 13). While the front end of the nose piece 81 may be configured as desired, in the embodiment shown it is convexly rounded forward in a generally spherical manner as indicated at 84. Although the nose piece can be configured to perform a variety of surgical, patient tissue working

operations, in the particular unit shown, the nose piece 81 is provided with a sloped planar relief defining the angled shearing outer window 46, same being provided with a sharp shearing edge 85 for shearing coaction with the above mentioned inner window 47 of the inner tube 42 hereafter discussed. The radial interior diameter reduction, or necking in, of the nose piece 81 with respect to the rearward cylindrical portion 80, provides a close radial shearing fit with the exterior of the front portion of the inner tube 42.

[0074] The elongate cylindrical rearward portion 80 of the outer tube 32 includes an irrigation liquid inlet port 90 (FIGS. 11 and 12) axially positioned to align with and be centered on the irrigation liquid through passage 74 of the nipple 73, when the mounting hub 31 is assembled on the outer tube 32. The irrigation liquid inlet port 90 is preferably substantially D-shaped, with the straight edge of the D-shape at the forward end of the port 90 and the curved portion of the port 90 extending rearward therefrom. The hole 90 is preferably formed in the outer tube 32 by wire EDM or, any other convenient means, such as by transverse (chordal) milling, with an appropriately shaped milling wheel perimeter cross section. The substantially D-shaped configuration of the port 90 facilitates snug telescoping of the rigid plastics mounting hub 31 over the rear end portion of the outer tube 32 during assembly by reducing any tendency of the edges of the hole 90 to gouge the inside of the mounting hub during relative axial motion therebetween as assembly is being carried out.

[0075] In the preferred embodiment, a heated metal outer tube 32 is pressed coaxially forward or rearward into a somewhat undersized bore 33 in a thermoplastics material mounting hub 31, which provides, after the metal tube cools, a rigid fixed coaxial joiner between tube 32 and hub 31.

[0076] Given a mounting hub 31 of thermoplastic material, insertion of a heated metal outer tube 32 tends to soften the engaged portion of the thermoplastics mounting hub to allow easy pressed insertion of tube into mounting hub, whereafter cooling of the tube allows the mounting hub to recontour its inner bore to closely fit and harden about the cooled metal tube. To further facilitate fixed connection of tube to hub, it may be desired to externally knurl, or otherwise surface roughen, the rear end portion of the outer tube 32 in spaced relation to the rear of the hole 90, as for example schematically and partially indicated at 92 in FIG. 15. Alternately, the knurling is extendably over the entire area in contact with the hub 31.

10 [0077] Upon rearward sliding of the rear end of the heated metal outer tube 32 into the bore 33 of the mounting hub 31, the sloped curved edge 91 of the rear portion of the hole 90 tends to slide rearward easily past the rear end of the through passage 74 (FIG. 6) without risk of distorting or partially closing same and so avoids the risk of reducing irrigation flow cross section through the assembled housing 30.

15 [0078] Turning now to the inner rotor 40 in more detail, the rotor hub 41 (FIGS. 19-21) has a preferably cylindrical, rear opening coaxial recess 100. The rear part of the recess 100 has diametrically opposed rear opening notches 101 (here two pair thereof) separated by rear extending fingers 102. The rear ends of fingers 102 are preferably rounded, at least in their radially outer parts and in the rear end portions of the notches 101.

20 [0079] Generally in the manner shown in U.S. Pat. No. 5,192,292, assigned to the assignee of the present invention, a coil compression spring 103 (FIG. 4) is received in and protrudes rearwardly (when at rest) from the recess 100 peripherally walled by the fingers 102. With the tool 12 chucked in the handpiece 11 (FIG. 1), the front end 104 of

the shaft of the powered rotation source 15 inserts into the rotor hub recess 100 (FIG. 4) to compress the spring and thereby urge the inner rotor 40 forward with respect to the housing 30. A diametral cross-pin 105 has outer ends received in diametrically opposed ones of the notches 101 for rotatably driving the circumferentially flanking ones of the fingers 102 and thereby rotating the inner rotor 40.

[0080] The suction hole 52 preferably is substantially D-shaped, as seen in FIG. 21, with the flat edge 110 thereof rearmost and separated from the rear recess 100 by a transverse wall 111 which may thus be diametral, flat, and relatively thin. As seen in FIG. 5, the suction hole 52 extends diametrically through the rotor hub and the rear end portion of the inner tube 42 extends rearwardly part way into the suction hole 52 for direct communication of the suction bore 44 of the inner tube 42 with the transverse suction hole 52, and thereby with the suction source SU when the tool 12 is chucked in the handpiece as seen in FIG. 1.

[0081] The inner tube 42 comprises an elongate substantially cylindrical rearward portion 120 carrying a coaxial front end portion 121, which in a particular unit shown is closed except at the front portion of the window 47, the latter being formed in the elongate cylindrical portion 120, as seen in FIGS. 23 and 25. In the embodiment shown, the interior surface of the elongate cylindrical portion 120 defines the bore 44 and is substantially cylindrical, and hence of substantially constant diameter, throughout its length.

[0082] In contrast, the elongate intermediate outer periphery 122 of the inner tube 42 is of diameter reduced from, but coaxial with, the rear and front outer peripheral portions 123 and 124 of the periphery 122. Rear and front portions 123 and 124 act as rear and

front radial thrust bearings, respectively, to rotatably support the inner tube 42 within the outer tube 32.

[0083] The front radial thrust bearing portion 124 is circumferentially interrupted by a longitudinal irrigation liquid channel 130 which communicates from the intermediate  
5 outer peripheral portion 122 of the inner tube substantially to the inner tube front end. An irrigation liquid port 131 (FIGS. 23-25) extends through the peripheral wall of the front outer peripheral portion 124 and communicates between the bore 44 of the inner tube and the longitudinal irrigation liquid channel 130. Preferably the port 131 is centered circumferentially on the channel 130 and both are diametrically opposed to the window  
10 47. In the embodiment shown, the port 131 opens through the irrigation liquid channel 130 near the front end thereof and is spaced slightly rearward from the rounded front end portion 121.

[0084] In the preferred embodiment shown, the channel 130 is conveniently an axially elongate chordal flat in the outer periphery of the forward portion 124, which flat 130  
15 extends rearward somewhat into the intermediate peripheral portion 122 of the inner tube and is of sufficient radial depth as to flatten the periphery of the reduced diameter intermediate portion 122. The port 131 and channel 130 each can be formed by any convenient means, e.g. EDM or a simple tangential grinding or milling pass across the periphery of the inner tube.

20 [0085] The port 131 is conveniently formed by a chordal flat 132 incised sufficiently deeply into the periphery of the inner tube 42 as to open into the bore 44. The chordal flat 132 is circumferentially somewhat wider than, and axially much shorter than, the chordal flat 130.

[0086] Although windows 47 of various forms are contemplated, in the embodiment shown in FIGS. 23 and 25, the window 47 through most of its length extends substantially along a chordal plane of the inner tube 42 and occupies close to but less than half the circumference of the inner tube 42. Also in the embodiment shown in FIGS. 23 and 25, the chordal edges of the window 47 are provided with teeth 133 spaced longitudinally therealong.

[0087] The rear portion 123 of the inner tube 42 is telescopingly fixed in the front opening bore 43 of the rotor hub 41, as shown in FIG. 5, by any convenient means, for example in the manner above described with respect to fixing of the outer tube 32 in the mounting hub 31. For example, the rotor hub 41 is preferably of a thermoplastic material for receiving the heated rearward portion 123 of the inner tube 42 to, upon cooling, fixedly grip the latter. Again, to facilitate fixed gripping, the rearwardmost part of the inner tube rear portion 123 may be surface textured, as by knurling 134 (FIG. 22), if desired.

[0088] With the outer housing 30 and inner rotor 40 each assembled in the manner above discussed, the tool 12 can be assembled by simply inserting the inner tube 42 forwardly into the open rear end of the outer tube 32 and its surrounding mounting hub 31, in the manner generally indicated in FIGS. 4 and 5.

[0089] When thus assembled, and as seen in larger size in FIG. 5A, the front end portion of the inner tube is supported by rotating bearing contact of its front outer periphery 124 by the inward stepped nose piece 81 of the outer tube 32 across the bearing clearance gap 135 of approximately 0.001 inch. The rearward portion 123 of the inner tube 42 is supported rotationally by the rear end portion of the outer tube 32 across a



bearing clearance gap 136 of approximately 0.0035 inch. The irrigation liquid inlet port 90 of the outer tube 32 supplies irrigation liquid radially inward to an annular fluid passage 140 having a radial thickness of about 0.007 inch. Irrigation liquid flow is represented by the arrows in FIG. 5A and passes forward through the annular flow passage 140, then through the longitudinal irrigation liquid channel 130 formed by the corresponding chordal flat, and then forward beyond the step 83 in the outer tube 32 and radially inward through the port 131 into the interior of the inner tube 42.

[0090] The assembled tool 12 is chucked, as above discussed, with the tool circumferential rib 71 trapped behind the balls 65 (FIG. 7) to hold the outer housing 30 of the tool 12 fixed in the handpiece chuck 61 and wherein the rear end of the rotor hub 41 and its spring 103 engage the rotatable shaft 104 and its drive pin 105 in the manner discussed above with respect to FIG. 4, for rotating the inner rotor 40 with respect to the outer housing 30 of the tool.

[0091] Irrigation liquid flow, in accord with the arrows in FIG. 3, passes radially inward through the port 131 in the inner tube and into the forward portion of the interior thereof opposite the windows 46 and 47. If suction is not applied to the inner tube 42, the irrigation liquid then flows out through the rotating inner tube window 46 and fixed outer tube window 47 into the surgical site SS for supplying the latter with irrigation liquid.

[0092] On the other hand, when suction is applied to the rear end of the inner tube 42, as in FIG. 2, such suction tends to pull rearward, through the inner tube 42, irrigation liquid and entrained surgical debris drawn through the periodically radially aligned windows 46 and 47 from the surgical site.

[0093] If desired, the handpiece 11 itself may be provided with the user operator control for controlling rotation of the tool 12 and/or suction in a conventional manner and for this purpose a user thumb actuable push button control 141 is shown in FIG. 8.

[0094] FIGS. 29 and 30 show a modified cutting window 46A of the fixed outer tube wherein the opposite sides of the window 46A of the outer tube 32A have a series of notches 142 formed therein, leaving the sides of the modified window 46A defined by a plurality of teeth separated by such notches 142. The teeth 142 coact with the teeth 133 in the window 47 of the rotating inner tube 42. It has been found by the Applicant that the toothed (at 143) window 46A of the modified outer tube 32A provides a more aggressive cutting action than the untoothed window 46 of the outer tube 32 of FIG. 15.

[0095] Irrigation liquid flow rearward from the irrigator inlet port 90 has not been significant, and thus is believed a result of the path of least resistance to irrigation flow being forward from the port. Thus, while no liquid seal rearward of port 90 has been needed, a modification is contemplated which, as shown for example in FIG. 5B, provides an annular seal member 144 (e.g. of Teflon.TM. or other conventional seal material) sealingly interposed between the fixed housing 30B and inner rotor 40B (here between the opposed ends of the fixed and rotating hubs 31B and 41B), behind the port 90 (FIG. 5).

[0096] Turning now more particularly to the console 13 and tube set 14, the console 13 (FIG. 35-38) includes a case 151 and a mounting plate 150 which forms a portion (the left front portion in FIG. 1) of the case 151. The mounting plate 150 is preferably of a rigid molded plastics material. The mounting plate 150 has a motor 152 (FIG. 37) mounted to extend fixedly rearwardly therefrom. The motor 152 is fixed on the mounting

plate 150 through any convenient means, here including a fixed rigid carrier member 153. The motor 152 has a rotatable shaft 154 extending forward through a hole 155 in the mounting plate 150. A peristaltic pump rotor 160 is fixed on the shaft 154 for rotation therewith in front of the mounting plate 150.

5 [0097] In the embodiment shown, the rotor comprises axially opposed, preferably identical, generally triangular, front and rear roller carriers 161 and 162 (FIG. 37). The roller carriers 161 and 162 each comprise a substantially radially extending, generally triangularly plate 163 and plural (here 3) pairs of coaxially opposed stub shafts 164. In the embodiment shown, the carriers 161 and 162 are of molded plastic and the stub shafts 10 164 are recessed at their opposed free ends to minimize the amount of plastics material required. Each coaxially opposed pair of stub shafts 164 rotatably supports a generally spool-shaped, coaxial, peristaltic pump roller 165. The roller carriers 161 and 162 are fixed on the shaft 154 by any convenient means, for example by sandwiching axially between diametral through pins 170 fixedly diametrically extending from the motor shaft 15 154 adjacent front and rear ends of the shaft and engaging corresponding diametral depressions in the axially opposite sides of the plates 163. In this way, the carriers 161 and 162 are held against axial separation so as to reliably rotatably support the rollers 165 and are positively rotatably drive by the motor shaft 154 and thereby for orbiting the pump rollers 165 by rotation of the motor shaft 154. Thus, rotation of the motor shaft 20 154, in response to energization of the motor 152, rotates the peristaltic pump rotor 160 and thereby orbits the rollers 165 for peristaltic pumping with respect to the peristaltic pumping portion of the tube set hereinafter discussed.

[0098] To facilitate assembly, the front end of shaft 154 may be recessed and the front (outer shaft end) pin may be diametrically prefixed in an axial plug 169. The carriers 161, 162 and rollers 165 may first be installed on the motor shaft 154. Then, the pinned plug 169 is axially inserted and fixed (e.g. by adhesive) in the recessed front end of the motor shaft 154, to fix the carriers 161, 162 on the motor shaft 154.

[0099] The mounting plate 150 has a forward step 171 spaced below the pump shaft 154 (FIG. 35) with a concave semicircular hollow 172 below the rotor 160 and sized and shaped to loosely accommodate the orbiting rollers 165.

[00100] An arcuate cam 173 protrudes fixedly forward from the mounting plate 150. The cam 173 is semi-circularly concave toward the rotor 160 and hence longitudinally (in FIG. 35 downward) along the mounting plate 150. The concave face 174 of the cam 173 faces toward and extends circumferentially close along just outside the orbit of the rollers 165 of the pump rotor 160. On the other hand, the front face 175 of the cam 173 is a sloping ramp-like surface angled to face forward and longitudinally away from the rotor 160 (upward in FIG. 35) for purposes appearing hereafter.

[00101] The mounting plate 150 (FIG. 35) has parallel, longitudinally extending (extending vertically in FIG. 35), laterally spaced slots 180 therethrough. The bottom portions of the slots 180 are spaced on opposite sides of the cam 173 and extend at least to the bottom thereof (here slightly below same). Substantially at the level of the top of the cam 173, the slots 180 widen away from each other to form widened mouths 181.

[00102] Recesses 182 in the front face of the mounting plate 150 are well spaced above the cam 173 and extend upward in slightly vertically overlapping fashion above the slots 180. The recesses 182 are laterally spaced from each other and laterally spaced inboard

of the slots 180. The space between the recesses 180 is approximately the width of the cam 173, here slightly greater. The recesses 182 have laterally opposed, laterally inwardly projecting, wedge shaped portions 183, including laterally inward and upward facing, angled ramps 184 terminating in downward facing steps 185.

5 [00103] The mounting plate 150 also has laterally spaced, parallel, longitudinally aligned, guide grooves laterally spaced closer to the recesses 182 than to each other, longitudinally overlapping both the recesses 182 and slots 180, and overlying, in vertically spaced relation, the cam 173.

[00104] The tube set 14 includes a cassette 190 (FIGS. 1 and 31-34). The cassette has  
10 a body 191 having longitudinally spaced top and bottom ends 192 and 193 and laterally spaced sides 194. The body 191 has a plate-like front wall 195 bounded by the ends 192 and 193 and sides 194. The body 191 includes a concave backing wall 200 (FIGS. 32 and 34) which extends rearward from the front wall 195 thicknesswise of the body 191. The concave backing wall 200 is semi-circular and opens concavely toward one end of the  
15 body, here the bottom end 193.

[00105] The cassette body, as seen from the rear in FIGS. 32 and 34, is provided with plural reenforcing ribs 212 extending rearward from the front wall 195 to provide adequate strength to the body 191 while limiting the amount of material required. Such body is preferably formed by molding of a suitable plastics, hardenable material.

20 [00106] A peristaltic pumping hose 201 (FIG. 32) has a pumping portion 202 backed by the concave backing wall 200 and inflow and outflow portions 203 and 204 respectively extending from the cassette 190 and flanking the pumping portion 202. The inflow portion 203 of the pump hose 201 is provided with a suitable connector 210 at its free,

upper end, for connection in a conventional manner to a irrigation liquid source such as the irrigation liquid bag IB in FIG. 1 and may be provided with a conventional removable clamp 211 for controlling flow from the bag IB.

[00107] The inflow hose portion 203 is led down into the cassette body 191 through a  
5 hole 205 in the cassette body top wall 192. An L-shaped keeper bar 218 (FIGS. 32 and 34) fixedly extends from one side wall 194 of the body 191 (the left side wall in FIGS. 32 and 34) intermediate the top most two lateral ribs 212 and opens forward toward the hose portion 203 to prevent its rearward escape from the adjacent notches 213. The inflow hose 203 is led through notches 213 in various of the ribs 212 down and to one  
10 side (the left in FIG. 32) of the downward opening concave backing wall 200 and sealingly and fixedly connects to an elbow 214 at one of the notches 213 in the adjacent rib 212. The other end of the elbow 214 points laterally into the space below the downwardly concave backing wall 200 and sealingly and fixedly connects to the left (in FIG. 32) end of the flexible peristaltic pumping hose 202. Opposed slightly rearward  
15 converging steps 217 extend rearward adjacent the corresponding notches 213 in the lower left (FIGS. 32 and 34) corner of the body 191 where the hoses 203 and 202 fixedly and sealingly interconnect by sleeving over the grooved ends of the elbow 214. The convergent pairs of steps 217 each form an undercut into which the corresponding end portion of the corresponding hose 203 or 202 is forcibly and resiliently forwardly pressed  
20 at a point where the corresponding hose passes over an annularly grooved portion of the elbow 214, so as to frictionally and through an interference fit tend to prevent rearward escape of the elbow 214 and corresponding hose ends of the hoses 202 and 203 out of the body 191.

[00108] In the embodiment shown, a straight line fitting 215 fixedly and sealingly connects the hose portions 202 and 204 (here at the right side of the body 191 as seen from the rear in FIG. 32). A preferably integral, U-shaped undercut spring clip 216 extends rearward from the cassette front wall 195, as seen in FIGS. 32 and 34. The spring clip 216 grips snugly, in snap fit fashion, the soft deformable hose pumping portion 202 where it surrounds a grooved portion of the straight line fitting 215. The fitting 215 is thus fixedly held in place on the cassette body 190. The outflow hose 204 extends laterally from the cassette body 190 by means of another notch 213 rearward opening in the corresponding side 194 of the cassette body.

10 [00109] The cassette has laterally spaced legs laterally flanking the concave backing wall 200 (FIG. 34) and spaced on opposite sides thereof. The legs 220 are located between the ends 192 and 193 of the body 191 adjacent the central portion of the backing wall 200. The legs 220 extend rearward from the body sides 194. Feet 221 on the rear ends of the legs 220 extend laterally (here outwardly) therefrom for blocking forward displacement of the cassette away from the mounting plate 150 of the console as hereafter discussed.

15 [00110] The cassette further has a laterally spaced resilient leaf spring-like arms 222 extending rearward from the body 191 and angled laterally rearwardly and away from each other. The arms have rear tips 223 for blocking longitudinal displacement of the cassette 190 with respect to the console mounting plate 150. The laterally outer faces of the arms 222 are preferably textured as indicated at 224 (for example by means of grooves or ridges transverse to the length of the arms) to facilitate gripping between the thumb and a finger of the user for squeezing, and thereby bending, the arms 223 laterally toward each other to thereby bring the tips 223 laterally closer to each other. In the

preferred embodiment shown, the arms 222 are molded integrally with the body 191 and connect therewith at the front face 195, the arms 222 extending rearward in an elongate, angled fashion so as to protrude and somewhat beyond the rear extent of the body. In the preferred embodiment shown, the body sides 194 are necked in laterally toward each other as indicated at 225 to form laterally outwardly concave recesses, such that the arms 222 are contained laterally in such recesses 225 and their tips 223 are, at rest, substantially closer together laterally than are the feet 221.

[00111] Holes 219 in the plate-like front wall 195 of the body 191 are located in front of the above described spring clip 216, rearward convergent step pairs and L-shaped keeper bar 218, as indicated in FIGS. 31 and 33, and are here left by special mold inserts (not shown) which are placed to form the spring clip 216, step pairs 217 and L-shaped keeper bar 218 during the molding of the cassette 190.

[00112] The cassette body 191 further includes a pair of parallel, longitudinally (vertically in FIG. 34) aligned, guide ridges 230 which extend rearward from the rear plane of the cassette body 191. In the preferred embodiment shown, the guide ridges 230 are rearward extensions of the sides 194 at the minimum separation of such sides in the recesses 225. The guide ridges 230 are thus, in the embodiment shown, flanked at least at their top portions by the arms 222, as seen in FIG. 32.

[00113] The concave backing wall 200 in its major central portion has a relieved and sloped rear edge 233, which is sloped to face rearward and downward (in FIG. 32) at an angle complementary to the sloped front face 175 of the arcuate cam 173 on the mounting plate 150 of the console. The sloped relieved rear edge 233 extends upward and rearward into ones of the reenforcing ribs 212 which converge toward and back the top of the



concave backing wall 200. The relieved sloped portion of the rear edge 233 of the concave backing wall 200 extends almost the entire width thereof, in the embodiment shown ending at 234 at a sufficient lateral width to clear the lateral ends of the arcuate cam 173 on the mounting plate 150 of the console.

5 [00114] The central portion 240 (FIG. 32) of the cassette bottom 193 is open to clear the orbiting pump rollers 165. A convexly rounded portion 241 of the cassette plate-like front wall 195 extends down below the cassette bottom 193 to cover the orbit of the pump rollers 165 and to fit snugly in a front edge recess 242 (FIGS. 35 and 36) of the hollow 172 at the bottom of the mounting plate 150 of the console.

10 [00115] As shown in FIGS. 1A, 1B, 39A-39H, 40A-40J, 41A-41J, and 42A-42E, in another aspect of the present invention, the tube set 14 is contained within an insertable cassette 302 which may be inserted and removed from the console 13 (see FIGS. 1A and 1B). As discussed below, the insertable cassette 302 has an external portion 304 and a pump engaging portion 306. In use, the insertable cassette 302 is inserted into an  
15 aperture 308 of the console 13. When installed the external portion 304 is external to the console 13 and the pump engaging portion 306 is internal to the console 13.

[00116] The console 13 includes a base 310 having a bottom 312, a back wall 314 and a front wall 316. A front bezel panel 318 may be snapped onto the front wall 316 in a conventional manner. The front bezel panel 318 may house a user interface (see above).

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[00117] A pump housing 320 is mounted to the base 310. The pump motor 152 is coupled to the pump housing 320 by any conventional means such as screws, bolts, or

clips. As shown the pump motor 152 and the rotatable shaft 154 may be parallel to the front wall 316.

[00118] As shown, the aperture 308 is within the front wall 316. The front bezel panel 318 has a corresponding aperture 322 which is aligned with the aperture 308 in the front wall 316 when assembled.

[00119] The peristaltic pump rotor 160 is fixed on the shaft 154 for rotation therewith as discussed above. As discussed above, the peristaltic pump rotor 160 includes a set of pump rollers 165. When the shaft 154 is rotated by the motor 152, the rollers 165 compress a portion of a hose or tube (see below) to provide a pulsatile flow of irrigation fluid.

[00120] The insertable cassette 302 includes locking mechanism 324 for maintaining or holding the insertable cassette 302 in the console 13 after the insertable cassette 302 has been inserted and for controllably releasing the insertable cassette 302 when desired.

[00121] With specific reference to Figures 39B-39H, in a first embodiment, the insertable cassette 302 includes a cassette housing 326 which may be one piece. The external portion 306 of the insertable cassette 302 includes a beveled aperture 328 with in a front surface 329 for receiving a locking lever 330. As shown most clearly in Figure 39B, the locking lever 330 includes first and second sides 332A, 332B connected at a first end to a pushing portion 334. Each side 332A, 332B includes an aperture 336 (only one of which is shown) located generally in the middle of the respective side 332A, 332B.

When assembled as shown in Figures 39C-39H, the apertures 336 snap over and around respective pivot points 338 (only one of which is shown) located on the cassette housing 326 thereby allowing rotational movement of the locking lever 330.

[00122] The locking lever 330 is adapted to move to an between a locking position (shown in 39G and 39H) and an unlocking position (shown in Figures 39A-39F). The cassette housing 326 includes a pair of detents 340 (only one of which is shown) located on each side. Each side 332A, 332B includes a locking detent aperture 342A, 342B and  
5 an unlocking detent aperture 344A, 344B adapted to engage the respective detent 340 when the locking lever 330 is in the locking position and the unlocking position, respectively.

[00123] The insertable cassette 302 includes first and second tube connectors 346A, 346B which in the illustrated embodiment are integral with the cassette housing 326. An  
10 inlet tube 348A is connected to one end of a the first tube connector 346A and an outlet tube 348B is connected to one end of the second tube connector 346B. As shown most clearly in Figure 39C, the cassette housing 326 includes a rear cavity 350 having a concave pumping wall 352. A compressible tube 348C has first and second ends connected to the opposite end of the first and second tube connectors 346A, 346B,  
15 respectively. The compressible tube 348C has a middle portion 354 have a shape similar to the concave pumping wall 352. When assembled, the compressible tube 348C is fit between the concave pumping wall 352 and the peristaltic pump rotor 160.

[00124] As shown in Figures 39E and 39F, to insert the insertable cartridge 302 in the console 13, the locking lever 330 is in the unlocking position. The rear cavity 350 of the  
20 cassette housing 326 includes first and second side walls 356A, 356B, each having a slot 358A, 358B adapted to receive the shaft 154. Once the insertable cartridge 302 is inserted, the locking lever 330 may be moved into the locking position (see Figures 39G and 39H). The first and second sides 332A, 332B of the locking lever 330 each include

a shaft receiving slot 360A, 360B for receiving the shaft. Thus, the locking lever 330 engages the shaft 154 to ensure accurate and rigid positioning of the insertable cassette 302. As shown, the shaft receiving slots 360A, 360B are tapered to provide a low insertion force and acts to draw the insertable cassette 302 more fully into the console 13.

5 [00125] Once the insertable cassette 302 is locked into place, pumping can begin. To remove the insertable cassette 302, the locking lever 330 is moved from the locking position to the unlocking position and the insertable cassette 302 can then be removed.

[00126] A hinged door 362 may be used to seal or close the aperture 308 when the  
10 insertable cassette 302 has been removed.

[00127] A second embodiment of the insertable cassette 302 is shown in Figures 40A-40I in which like elements are referenced using the same reference numbers. The locking mechanism 324 includes an ejection bar 402 and a locking arm 404. The ejection bar 402 has a first end 406 which extends through an eject bar aperture 408 in the front bezel  
15 panel 318.

[00128] With specific reference to Figures 40A and 40E-40J, the pump housing 320 includes first and second portions 412A, 412B which are fastened together using appropriate fasteners such as screws 414 forming a cavity 416. A gasket 410 may be used to seal the pump housing 320. The pump housing 320 is mounted to the pump  
20 motor 152 using one or more screws 420. The rotating shaft 154 is inserted through a shaft aperture 418. The pump roller 160 is contained within the cavity 416 and is mounted to the shaft 154. A pair of bushings 421 may be coupled between the interior sides of the pump housing 320 and the pump roller 160.

[00129] With specific reference to Figures 40B-40D, the cassette housing 326 forms an input tube channel 422A and an output tube channel 422B which have a first open end 424A, 424B at the external portion 306 and a second open end 426A, 426B at the pump engaging portion 304. The pump engaging portion 304 further includes first and second integral clips 428A, 428B for receiving and retaining first and second tube connectors 430A, 430B. The input tube 348A is inserted through the input tube channel 422A and connected to the first tube connector 430A. The output tube 348B is inserted through the output tube channel 422B and connected to the second tube connector 430B. As in the first embodiment, the cassette housing 326 forms the concave pumping wall 352. The compressible tube 348C is connected to the first and second tube connectors 430A, 430B. The middle portion 354 of the compressible tube 348C generally follows the contour of the concave pumping wall 352. The cassette housing 326 further includes first and second grasping tabs 432A, 432B which are used to insert and remove the insertable cassette 302.

[00130] With specific reference to Figures 40A, 40F, 40H, and 40J, the locking arm 404 includes first and second arms 434A, 434B connected by a central portion 436. The first and second arms 434A, 434B include apertures 438 which are rotatably mounted on the pump roller 160. The central portion includes a tab 440. A biasing spring 442 is connected to the tab 440 at one end and to a post 444 of the cassette housing 302. The biasing spring 442 acts to bias the locking arm 404 into a locking position (shown in Figures 40F and 40J).

[00131] The first and second arms 434A, 434B have a ramping portion 446 and a notch 448. The first and second portions 412A, 412B include locking post 450 (only one of

which is shown. As the insertable cassette 302 is inserted into the console 13, the locking post 450 engages the ramping portion 446 of each arm 434A, 434B. This acts against the force exerted on the locking arm 404 by the biasing spring 442. As the insertable cassette 302 is inserted, the locking arm 404 is pivoted away from the locking position (see Figure 40H). When the insertable cassette 302 is fully inserted the ramping portions 446 no longer engage the locking posts 450. The locking arm 404 rotates back to the locking position with the locking posts 450 within the notches 448 (see Figure 40J).

[00132] As shown in Figure 40A, the locking arm 404 further includes an extension 452 extending away from one of the first and second arms 434A, 434B. The extension 452 includes an aperture 454 which receives a post 456 on a second end 458 of the ejection bar 402. To release the insertable cassette 302, the user pushes the ejection bar 402 inward (towards the console). This exerts a force on the extension 452 which may cause the locking arm 404 to rotate away from the locking position. Once the locking posts 450 are no longer within the notches 448, the central portion 436 engages insertable cassette 302. Further motion of the ejection bar 402 rotates the locking arm 404 thereby pushing the insertable cassette 302 out.

[00133] With reference to Figures 43A and 43B, in one embodiment the pump roller assembly 160 includes first and second interlocking hubs 460A, 460B. The first and second interlocking hubs 460A, 460B are generally circular. The first and second interlocking hubs 460A, 460B snap together and have D-shaped apertures 462 for receiving the rotating shaft 154. In the illustrated embodiment the pump roller assembly 160 include three pins 464A, 464B, 464C and three corresponding flanged rollers 466A, 466B, 466C. Each roller 466A, 466B, 466C has a center aperture for receiving the

respective pin 464A, 464B, 464C. The ends of each pin 464A, 464B, 464C fit through slots 468 in the interlocking hubs 460A, 460B and washers 469 and include a groove 470 adjacent both ends. The slots 468 are elongated and oriented in a radial fashion from the center of the respective hub 460A, 460B. The slots 468, thus, permit the pins 464A, 464B, 464C to slide from one end to the other. Each hub 460A, 460B includes a plurality of clip retaining portions 471 and a plurality of ridges 472 along the outer perimeter of the outer surface of the hubs 460A, 460B. A plurality of generally U-shaped springs 474 are fitted around the clip retaining portions 471 at one end. The other end of the springs 474 are fitted within the grooves 470. The springs act to bias the rollers 466A, 466B, 466C in an outward direction from the center of the pump roller 160.

[00134] A third embodiment of the insertable cassette 302 is shown in Figures 41A-41J in which like elements are references using the same reference numbers. The locking mechanism 324 includes a locking lever 502 rotatably coupled to the shaft 154 at a first end 504. The locking lever 502 has a second end 506 which extends through the corresponding aperture 322 in the front bezel panel 318. An engagement portion 506 extends transversely from the second end 506. The locking lever 502 is moveable between a locking position (shown in Figures 41I and 41J) and an unlocking position (shown in Figures 41G and 41H). As shown, in the locking position, the engagement portion 506 engages a front edge of the insertable cassette 302 preventing its removal.

20

[00135] With specific reference to Figures 41B-41D, the cassette housing 326 includes a first half 510A and a second half 510B which may be snapped together or joined using any suitable means. First and second tube connectors 512A, 512B couple the tubes

348A, 348B, 348C. Each half 510A, 510B may include a beveled portion 514 (only one of which is shown) to facilitate grasping of the insertable cassette 302. With specific references to Figures 41A, the pump housing 320 includes a first pump housing half 516A and a second pump housing half 516B. The first and second pump housing halves 516A, 516B are joined together using any suitable means forming a cavity 518 for housing the roller assembly 160 and the first end of the locking lever 502. The locking lever 502 includes an aperture 520 for receiving the shaft 154. A spring 522 biases the locking lever 502 into the unlocking position.

[00136] A fourth embodiment of the insertable cassette 302 is shown in Figures 42-42F in which like elements are references using the same reference numbers. The locking mechanism 324 includes a flexible, hinged locking finger 602 which may be integrally molded with the cassette housing 326 (see Figures C and E).

[00137] The pump housing 320 includes first and second portions 604A, 604B which fit together to enclose the end of the shaft 154 and the pump roller assembly 160. The first and second halves 604A, 604B may be fastened by any suitable means, such as screws, as shown.

[00138] The cassette housing 326 includes a first half 606A and a second half 606B which may be snapped together or joined using any suitable means. First and second tube connectors 608A, 608B couple the tubes 348A, 348B, 348C. Each half 606A, 606B may include a beveled portion 610A, 610B to facilitate grasping of the insertable cassette 302.

[00139] As shown, the hinged locking finger 602 may be molded integrally with the first half of the cassette housing 606A. In the illustrated embodiment, the hinged locking finger 602 forms a living hinge 612 at one end 614 allowing the hinged locking finger



602 to be flexed inward. A biasing means (not shown), such as a spring, may be used to bias the hinged locking finger in an outward direction.

[00140] The hinged locking finger 602 includes a tab 616 which includes a ramping portion 618 and an edge 620. As the insertable cassette 302 is inserted into the console 13, the ramping portion 618 engages an edge of the corresponding aperture 322 or the aperture 308, thereby moving the hinged locking finger 602 inward. When the cassette 302 is fully inserted, the tab 616 disengages from the edge and springs outward. The edge 620 of the hinged locking finger 620 maintains the insertable cassette 302 in the console 13. To remove the insertable cassette 502, the hinged locking finger 602 may be squeezed inward and the cassette 302 removed.

[00141] As shown in Figure 42C, the hinged locking finger 602 may also include an indicator 622. As shown in Figures 42F and 42G, the indicator 622 extends through a slot 624 in the cassette housing 326 and provides an indication of whether the hinged locking finger 602 is in the locked or unlocked position. Icons may be provided over the slot to provide a visual indication of the position of the hinged locking finger 602.

[00142] In an alternative embodiment, a hinged locking finger 602 may be provided on both sides of the insertable cassette 302.

[00143] With particular reference to FIGS. 42H, 43A, and 43B, each of the rollers 466A, 466B, 466C include at least one flange 467. In the illustrated embodiment, each roller 466A, 466B, 466C has a flange 467 at each end which controls compression of the compressible tube 348C between the rollers 466A, 466B, 466C and the concave pumping wall 352. The flanges 467 ensure a more consistent flow of liquid and increase the life of the compressible tube 348C.

[00144] As discussed above, four embodiments of a cassette 302 have been disclosed and described, which may be inserted into the console 13. In one aspect of the present invention, the cassette 302 may be shaped to permit only one orientation for insertion.

The insertable cassette 302 includes a locking mechanism 324 for automatic or manual  
5 locking of the cassette 302 within the console 13 once it has been inserted.

[00145] The cassette 302 may be formed from plastic and where required may be assembled by any suitable method, including by press fit, snap finger lock, ultrasonic welding, any suitable method, or combination of methods.

10

## OPERATION

[00146] In the preferred embodiment shown, the tube set 14 and tool 12 are each prepackaged, disposable, single use, presterilized (by the manufacturer) devices, the handpiece 11 is sterilizable, and the handpiece and console 13 are reusable, multiple use devices.

15 [00147] Prior to use, the console 13 is located in the surgical operating room remote from the operating table (or other patient support) and is connected to a suitable electric power source EP (FIG. 1) at least for powering the peristaltic pump motor 152, as well as any other control functions that may be provided, e.g., as indicated by the dotted lines 22 and 23, control of the handpiece power source PO and suction source SU.

20 [00148] The tube set 14 is readied for use (typically by removal from a sterile package). The cassette 190, 302 can then be installed in the console 13.

[00149] With the cassette 190, 302 thus installed, the orbit of the pump rollers 165, 466A-466C compress the hose pumping portion 202 or compressible tube 348C against the cassette concave backing wall 352 as discussed above.

[00150] To ready same for use, the handpiece 11 is connected through the cable 21 to  
5 the power and suction sources PO and SU respectively, as seen in FIG. 1. A tool 12 may then be chucked in the handpiece 11 and the irrigation outflow hose 204 from the cassette 190 may then be connected, as indicated at 73, to the irrigation liquid inflow fitting of the tool 12. If desired, the outflow hose portion 204 may be secured to the body of the handpiece 11 by any convenient releasable clip means, not shown. The irrigation liquid  
10 inflow hose portion 203 may then be plugged on at 210 into a conventional irrigation liquid supply bag IB.

[00151] In surgical use, the peristaltic pump, defined by the cassette 190, 302 and pump rotor 160 can be operated to supply irrigation liquid to the tool 12 and therethrough to the surgical site SS (FIG. 1). The peristaltic pump can be operated continuously by  
15 continuous energization of its motor 152 or discontinuously by turning on and off its motor 152. Turning on and off of the peristaltic pump motor may be accomplished by means near the surgical site such as a user operated foot switch or the like or by suitable switching on the console 13 in a conventional manner. If desired, means (not shown) may be provided on the outflow hose 204 to close or open flow therethrough and such means  
20 may be provided close to or on the handpiece for convenient use.

[00152] In use, the tool inner rotor 40 is rotated by the powered rotation source 15 of the handpiece 11, while the tool housing 30 is fixed with respect to the handpiece outer casing held by the surgeon. The rotating inner tube 42 thus rotates its inner window 47

repetitively passed the outer window 46 (FIGS. 2-4) of the outer tube 32 to accomplish a shearing type tissue cutting action. Tissue working can be accomplished with a variety of window configurations at 46, 47, including that shown in FIG. 4. For example, a more aggressive tissue cutting action can be accomplished by substituting the modified outer tube window configuration at 46A of FIGS. 29 and 30, with its teeth 142 in rotating cutting cooperation with the teeth 133 on the inner tube window 47.

[00153] As above discussed with respect to FIGS. 2 and 3, irrigation flow may be combined with suction flow (FIG. 2) or used alone to provide irrigation liquid to the surgical site.

10 [00154] As to the latter, and as schematically shown in FIG. 3, irrigation liquid flow through the fitting 73 and the annular flow space between the inner and outer tubes and thence through the port 131 provides irrigation liquid to the inside of the inner tube near its front end and thereby allows outflow of such irrigation liquid to the surgical site SS, through the windows 46 and 47 as they periodically mesh. On the other hand, when it is  
15 desired to remove debris from the surgical site, e.g. after cutting, provision of suction rearward through the inner tube 42 (as schematically indicated by arrows in FIG. 2) draws at least some of the irrigation liquid flowing into the inner tube through the hole 131 rearwardly along the inner tube to entrain and thereby retrieve unwanted debris from the surgical site SS.

20 [00155] The irrigation flow path between the inner and outer tubes has been described in detail above with respect to FIG. 5A, for example, and need not be repeated, as has the assembly of the tool 12 and its installation and removal from, the handpiece 11.

**[00156]** Although the invention has been disclosed in detail for illustrative purposes, it will be recognized that variations or modifications of the disclosed apparatus, including the rearrangement of parts, lie within the scope of the present invention.

**[00157]** Other aspects and features of the present invention can be obtained from a study  
5 of the drawings, the disclosure, and the appended claims.